Intersymblol Interference (ISI)

signal <-> bandwidth

channel's bandwidth limitation

Solutions to mitigate ISI

a) optimize transmitter, (channel), receivers' filters ⟹ end-to-end

b) equalization (receiver's side)

Zero ISI property:

signal → W

sampling frequency $> 2W$ → $T = \frac{1}{2W}$ sampling period

Samples that you take at each: $t = \frac{n}{2W}$

Output of the channel for the n^{th} sample $y_n(t) = a_n \operatorname{sinc}\left[2W\left(t - \frac{n}{2W}\right)\right]$

Total Output $y(t) = \sum_n y_n(t)$

$$= \sum_n a_n \operatorname{sinc}\left[2W\left(t - \frac{n}{2W}\right)\right]$$

Nyquist's Pulse Shaping Criterion

pulse shape function $p(t) \longleftrightarrow P(f)$

$$\sum_{K=-\infty}^{+\infty} P\left(f + \frac{K}{T}\right) = T, \quad |f| \leq \frac{1}{2T}$$

sample values:

$$p(nT) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases}$$

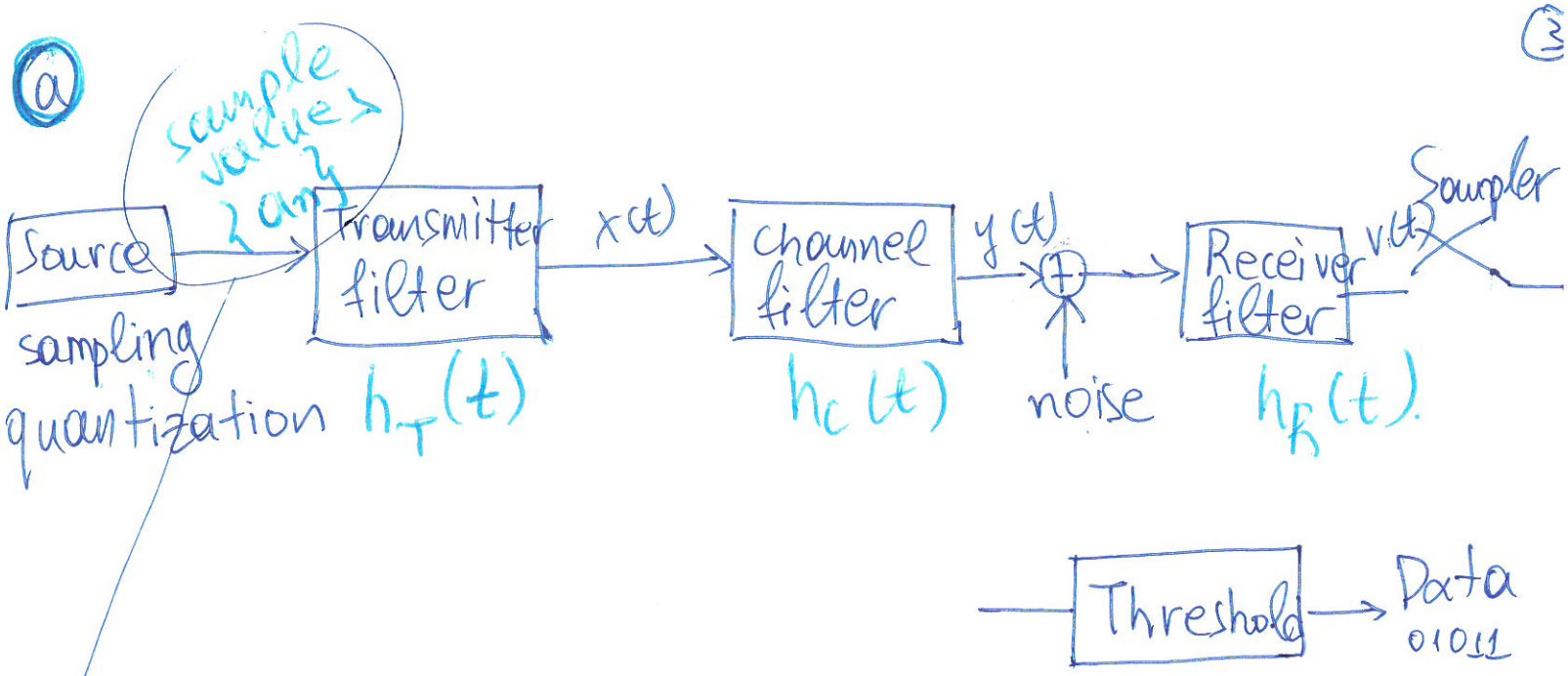
No adjacent pulses $\Rightarrow$ can impose interference.

The output of zero ISI $y(t) = \sum_{n=-\infty}^{+\infty} a_n p(t - nT)$

$\Rightarrow$ no ISI

$\Rightarrow$ no distortion

(a)



input to the transmitter filter.

Input to the channel filter

$$x(t) = \sum_{k=-\infty}^{+\infty} a_k \delta(t - kT) * h_T(t)$$

(sampling period)

$$= \sum_{k=-\infty}^{+\infty} a_k \, h_T(t - kT)$$

Output from the channel filter

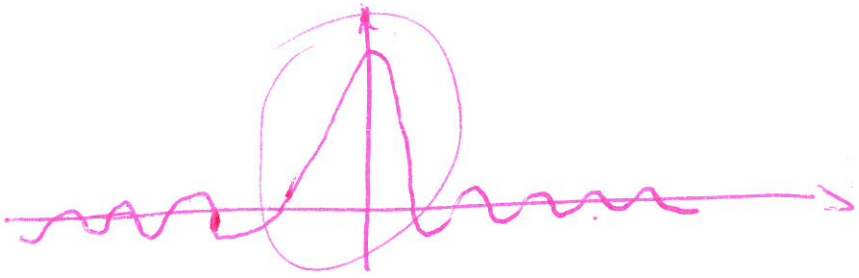
$$y(t) = x(t) * h_c(t)$$

$$v(t) = \sum_{k=-\infty}^{+\infty} a_k \cdot A \cdot p_{RC}(t - kT - t_d)$$

amplitude scaling

raised-cosine pulse function

delay



$$A \cdot p_{RC}(t - t_d) = h_T(t) * h_C(t) * h_R(t)$$

$$A\, P_{RC}(f) \cdot e^{-j2\pi f t_d} = H_T(f) \cdot H_C(f) \cdot H_R(f)$$

Amplitude Responses:

$$A \cdot P_{RC}(f) = |H_T(f)| \cdot |H_C(f)| \cdot |H_R(f)|$$

$$|H_T(f)| = |H_R(f)| = \left(\frac{A \cdot P_{RC}(f)}{|H_C(f)|} \right)^{1/2}$$